IPRO 334
Spring 2007 Midterm Report

Resource Consumption Awareness in the Home

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1.0 Revised Objectives

People are inadequately informed about their energy consumption behaviors in the home. Providing real time feedback at the point of decision making will enhance consumer awareness of energy consumption, and potentially lead to behavior modification. The IPRO 334 team will design and evaluate a means of improving energy consumption awareness in the home. Team 334 will determine what metrics are most valuable to consumers and the best means to communicate feedback.

During the course of the Spring 2007 semester, the IPRO 334 team will:

- Study existing technology and similar projects in the areas of energy consumption measuring and awareness
- Develop an ideal user profile, research the users' needs, and find suitable examples in the real world to use as test groups
- Based on user interviews, develop design criteria for the most effective means of communication to people about their consumption
- Design and prototype an interface providing the feedback determined in the design criteria
- Test the effectiveness of the prototype in a residential environment
- Compile data and draw conclusions on the prototype's affect on consumption awareness.
- Project our ideas to the future advances of the product including technology, marketing strategies, and business plans

2.0 Results to Date

User Profile:

The user profile has been identified as having three main attributes. Our ideal user would be someone who pays their own bills, is an early adapter (first wave consumer) and some who is forward looking (excited/concerned about the future).

Product Research:

There is a variety of products, both commercial and conceptual, whose aim is to make energy visible to the homeowner. We've identified three general product categories for energy-awareness products.

Diagnostic Tools:
Pros: detailed information about specific appliances
Cons: difficult to use, cannot easily see total energy consumption
Examples: Kill-A-Watt, current clamps (used by electrical technicians)

These are small, handheld tools that measure the energy consumption of individual appliances. These products require the user to plug in the appliances they want measure, hence they require a significant amount of effort from the user. These products also have several advanced data collecting features.

In-Home Energy Meters:
Pros: easily see real-time total energy consumption
Cons: difficult to track consumption of individual appliances
Examples: Power-Cost Meter, Centameter, The Energy Detective, Wattson, Building Dashboards

There are two sub-categories of in-home energy meters:
1. Portable energy display units

These products essentially take the confusing, analog power meter outside your house and map it to a portable digital display inside the house. The homeowner can take the energy meter anywhere in the house and see, in real-time, the amount of energy they are consuming. They also have the option of viewing energy consumption in terms of Watts or dollars. These products also typically display other useful information such as the time and date.

2. PC-based energy displays

These are very similar to the portable energy display units, except they use a PC to display and manipulate energy data. These products also tend to have additional advanced feature capabilities. For example, Building Dashboard displays a wealth of information about resource consumption to the homeowner via charts, graphs and animations. This info can be viewed on a home PC, electronic kiosk or other web-enabled computer devices.

Artistic / Para-Functional:

Pros: fun, aesthetic, thought-provoking

Cons: lack practical information and use-qualities

Examples: Wattson, projects by the Static! Group at the Interactive Institute (including the Power Aware Cord, Erratic Radio and Flower Lamp)

There are a wide range of products ideas whose aim is to cause the user to reflect on their relationship with technology and energy rather than to give practical feedback. There are three approaches typically used that may be considered more artistic than utilitarian.

1. Ambient Information:

The Power Aware Cord attempts to make energy usage visible by literally having a cord that lights up to reflect the amount of energy being used. The Wattson, which primarily functions as an in-home energy meter, also conveys the numerical energy information with colored lights that accomplish functional as well as aesthetic ends.

2. Subversive Technology:

These are products that turn-off or behave erratically when consuming too much energy. For example, the Erratic Radio "untunes" when excessive power is being consumed.

3. Equating Low Consumption with Aesthetics:
An example is the Flower Lamp, which "blooms" to become more beautiful when less energy is used.

Insights from Product Research
The insights from our product category research are summarized in a list of qualities we consider keeping, losing and adding to our design.

Keep
+ feedback on individual appliances
+ feedback on total household consumption
+ real-time feedback
+ dollar and wattage metrics
+ fun and engaging interaction
+ aesthetic appeal

Lose
+ required interaction from the user
+ complex setup

Add
+ prescriptive feedback or coaching
+ long-term goal evaluation
+ rewards and incentives

Metric and Feedback Brainstorming:
We began by brainstorming different metrics to communicate feedback to the users on their consumption habits. Four basic categories were formed to represent the metrics that were generated:

1. Products/Rewards:

- Coupons, Wish list of prizes, Rebates, Money Back on energy bill payments, Food/Drinks, Shoes

2. Numeric:

- Money, Kilowatt hours, watts

3. Ecological Impact:

- Ecological footprints (individual property, town), How many _____ (power plants, earths, landfills, oceans, forests, etc.) represent the amount of energy the household uses in a _____ (year/month/day)?

4. Sensory:

- Color, symbolic color, smell, vibration, lights (dim, brighten, dancing, flashing, etc.), sound (ambient noise, music, machinery, etc.)

We also brainstormed how best to display the feedback and can up with these ideas.

- Graphs, Charts, Mapping behavior and how it affects someone else

From this list of options, we began to integrate certain ones into the prototype system to test on subjects. We would then make conclusions about which ones were most effective.

Market Research:

The market research conducted to this point focused on three different alternatives. The first was where the product should be located. Based on the research, the largest energy consuming devices in the home are located in the kitchen. These include refrigerators, dishwashers, freezer, and electric

range and oven. Other major energy consuming devices include air-conditioning, space heating, lighting, and water heating.

Also researched was the initial cost of the product versus the long term benefits. An example that was found regarding this is the use of compact fluorescent light bulbs rather than incandescent light bulbs. The companies selling these light bulbs found that they needed to have a low enough price to sell them, because people are concerned with initial cost. This is especially true for landlords who do not want to pay the higher initial cost for something they are not paying for on a daily basis.

The final research shows the benefit of aligning our product with an already successful program. An example of a program that would be beneficial to associate with is Energy Star. Their popularity and stature would give our product high regard right from the beginning.

Test Phase 1

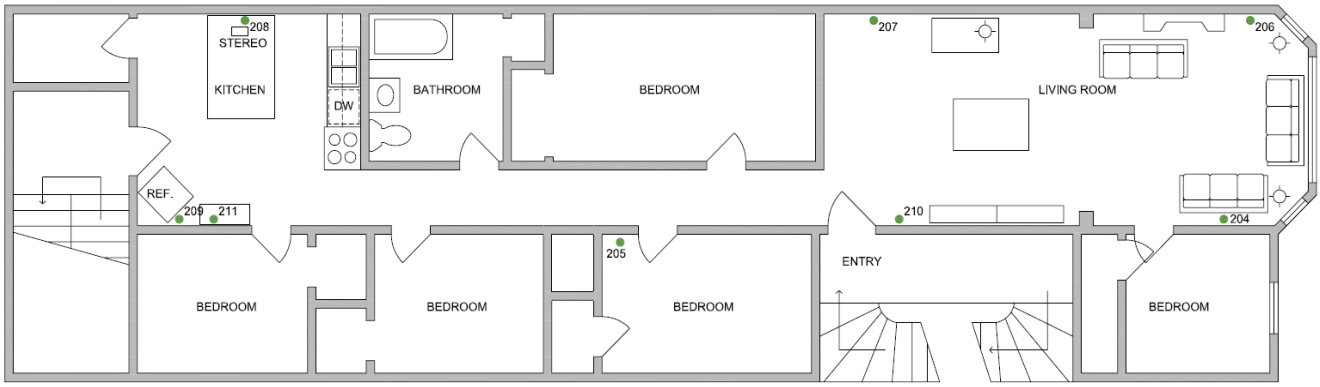
Prototype #1 Description:

The first prototype consisted of a computer screen and connecting wireless modules. The modules were connected to electric devices throughout the apartment of the test subjects. These modules sample the amount of current passing through an extension cord, and when it detects a change in the amount of current, it sends that sampled reading to a laptop. The computer screen displays a summation of kilowatts and a bar of color. The color ranges from green to red based on the amount of energy being used (red is near maximum, and green is all devices off).

Testing Procedure:

The first testing period lasted 3 days. It took place in an apartment with 6 residents. For this test, the screen was placed in the living room. This location was chosen because of its central location, and as an area where many of the

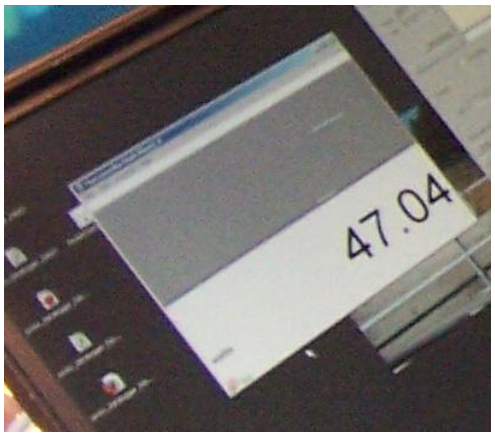
users spent time. As seen in the floor plan, 8 wireless modules were placed throughout the apartment and connected to the listed devices.



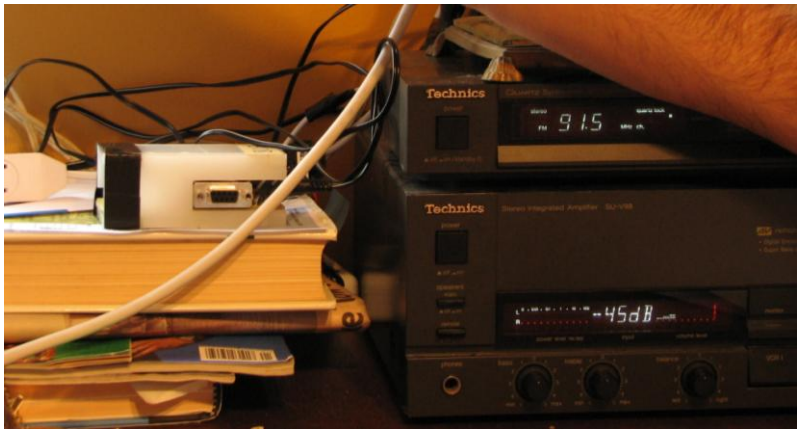
FLOOR PLAN
NOT TO SCALE

KEY

203 - IBM POWER CORD	208 - RADIO, SOUND SYSTEM
204 - LAMP	209 - REFRIGERATOR
205	210 - PRINTER, MONITOR, SPEAKERS, SOUND SYSTEM, LIGHT, CPU
206 - LAMP	211 - MICROWAVE, COFFEE MAKER, TOASTER
207 - TWO LAMPS	



Feedback Screen



Wireless module, attached to radio (208)

Graph of Data from Experiment

Testing Results:

During the test phase, users were encouraged to jot down thoughts about their experiences. We also interviewed the subjects after the test. We were also able to use the logged data to create a graph showing the usage history collected from each module. Through these experiences we learned a few key insights;

- seeing the feedback in an area close to the consumption point is important
- there are multiple modes of use including: immediate, peripheral, passive engagement, focused, active engagement
- active engagement decays over time as the "novelty" experience wears off
- the metric of kilowatts gave little meaning

Design Criteria Changes:

We then moved to improve the prototype for a second test period. To give users feedback in close proximity, we added a scale in the form of several

lights which corresponded with each wireless module. This would allow users to see the reaction of a device on the entire system without moving to the room with the computer screen. We also changed the information displayed on the computer screen. A large block of color corresponding with the wireless modules was displayed. A projected dollar value was also displayed based on the current energy usage. We hoped that a dollar value would give more meaning to the user than the kilowatt value.

Test Phase 2

Prototype #2 Description:

Prototype 2 still uses a centrally located display on a laptop screen, however the interface has changed. The screen now shows more than one numerical metric. The display now provides information in kilowatt-hours and dollars rather than just in watts. Each of these two values are averaged over the last 24 hour period and projected forward for a month. The display tells the user, "if you continue consuming at this current rate, you will spend $X in a month and use X kwh of energy in the same month." The display allows the user to toggle between the two numerical metrics, only showing one at a time. The screen also shows a colored square which changes from green, to yellow, to orange, to red to give a real-time representation of the home's total consumption where green represents low consumption and red represents high consumption. In addition to the centrally located display, prototype 2 features remote displays. Each device/appliance is connected to a remote LED light display. It has four LEDs of the same four colors used in the square on the main display and the color shown on the laptop screen is mimicked on the remote LED displays. These displays were installed near each of the devices being monitored to allow the user to see a real-time representation of the house's consumption without having to walk over to the main display. (See attached pictures of display interface and remote displays)

Testing Procedure:

The team developed a more organized testing procedure for the second installation. Four roles were designated according to different tasks that needed to be done during the installation and takedown.

Installation Procedure

People Needed

- *Narrator/Documenter* – Explains procedure to owner and answers all necessary questions. Documents all activities, including location of all devices and client responses.
- *Installer* – Decides where all devices will be located based on the response of the client as to which appliances are used most frequently.
- *Measurer* – Measures and records layout of living space and devices.
- *Draftsmen* – Drafts layout of the living space and device locations.

Time Line *(estimated)*

- Measuring and Layout – 45 minutes
- Installing and documenting devices – 1 hour
- Testing devices – 10 minutes
- Introduction and exit – 15 minutes
- **Total time of Installation – 2 hours and 10 minutes**

Order of Operations

Installation

- Arrive at client's house and as a group, introduce yourselves and thank them for their participation.
- Narrator asks for a showing of the most frequently used appliances in the house on a daily bases.
- Installer evaluates devices and determines which appliances to install the devices on based on the accessibility of the appliance.
- Draftsmen and Measurer split off to document the space.
- After Narrator explains and answers all questions Narrator joins Installers to document.
- Installers test installation of the devices and make sure everything is in proper order.
- Narrator gives final explanation of the journal entries and any final questions (include FAQ)

Take-Down

- Narrator reviews journal entries to make sure everything is clear then asks exit interview questions.
- Installer takes down all devices and returns everything to its proper manner.

Narrator's Script

Installation

(Upon entering the house)

Hi, my name is _____ and I am the team leader and contact for this project, thank you for all of you participation. (*Introduce everyone and what they will be doing throughout the*

visit) Why don't you start by showing us the house and which appliances you feel you use the most on a daily bases.

(Walk through of the house, Installer should be recording locations on appliances and accessibility of outlets, Measurer may break off and begin laying out the house.)

(After walk-through)
We would like to ask your permission to install devices on… *(list chosen appliances).*

(After client approves)
This is the device that we are installing *(show device)* this piece clips over the power cord and measures the amount of energy being used by the appliance. The device records the amount of energy used and sends the data to the computer screen and it shows up on a monitor. I'll show you more about the feedback when the devices are hooked up.

(Narrator joins the Installer to document the devices, this should take about a an hour)

(Show and explain the feedback to the client and make sure they fully understand the operation of the project)

The project will be installed for three days and you are asked to keep a journal. Make sure you date and time the entries and write what ever you feel about the product at that time.

Based on the information I have given you what are you expecting from this project?

(upon exiting)
Thanks again for your participation, again my name is _____ and here is my contact information in case you have any questions later on. We will be back on _____ at _____ to un-install the devices.

Take-Down
(Upon entering)
How did everything go?
(Insert closing interview questions here, Narrator records answers. Install takes devices and returns everything to its normal state.)

Testing Results:

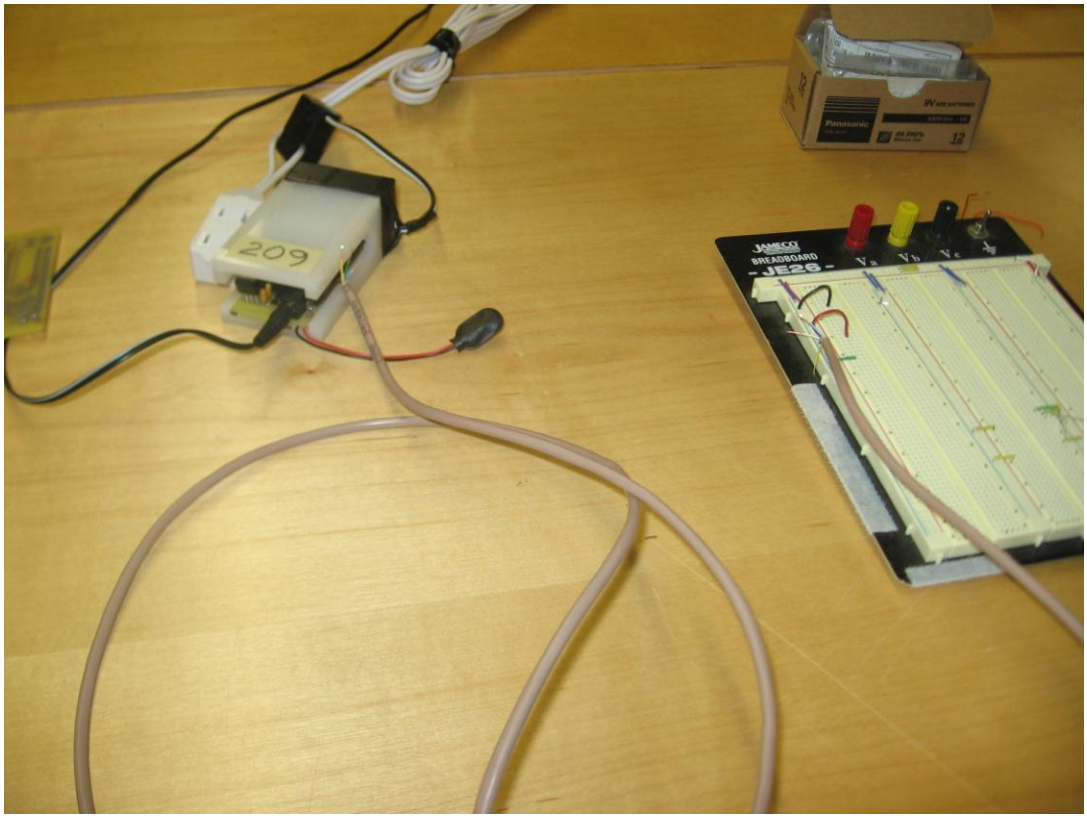
Unfortunately, the software had a bug and shut down after 10 hours of use, however this setback did not affect the value of information we gathered from the test. We generated a graph exactly like the last test's graph, but it only showed the first 10 hours of use. We were also adamant on taking pictures and using digital recording of the installation process. We have many pictures of the testing site and our prototype installed. The most valuable piece of data gathered was a video-recorded interview with the user after the test. The user was unaware that the system shut down after the first day of testing, but did notice that it was not working very well. She was intimidated by the display because of the fact that it was a laptop and she was afraid of

fiddling with someone else's computer. She was also confused by the directions she was given on how to interact with the display. The combination of the two made her apprehensive to interact with the display at all. However, she did mention that the location of the display was very effective because she could see it from most of the rooms in her house. She was interested in learning about the consumption of the individual devices and she had difficulty learning this from the prototype because the numerical metrics gave a projected estimation for a month's worth of usage rather than a record of immediate consumption. In regards to the colored method of feedback, she enjoyed seeing the colored LED displays from a distance and they were very effective for giving a real-time representation of the home's consumption. The only drawback was confusion for what exactly constitutes a color to change. It was difficult to understand what types of consumption behaviors would cause the color to change.

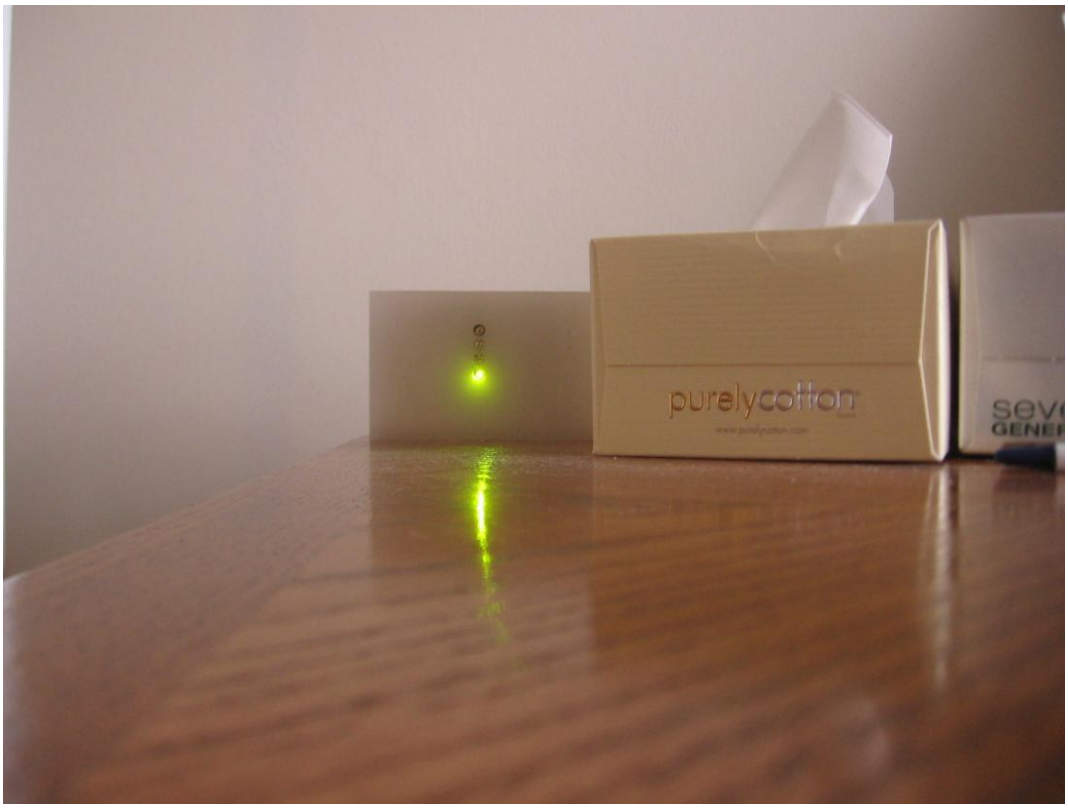
Design Criteria Changes:

Firstly, the laptop needs to be disguised to make it less intimidating for the user. It can be done in such a way to just leave the screen and one button exposed for simplicity of use. Another thing to adjust for the next test is to give a clear explanation of how to interact with the interface including an activity that the user(s) can see how the system works while the installers are present. This will give them an opportunity to ask questions and clear up confusion. Lastly, the interface should be re-worked to include both the metrics used in the first test and those used in the second. The display should show real-time consumption in watts as well as projected consumption in kilowatt hours and dollars and cents. This would give the user an opportunity to understand just how turning on a specific device in their home will affect the overall consumption of the house as well as what constitutes a color change. We can also give ourselves some constructive criticism on the overall testing procedure. It needs to be more precise and more structured.

After running two tests, we have learned what kind of things can go wrong and we can prepare for them ahead of time. Each role should be followed strictly so the users are not confused by four different people giving instructions. Although we have done a great job of this so far, we should continue to be considerate of the people we are testing and their property we are testing on.

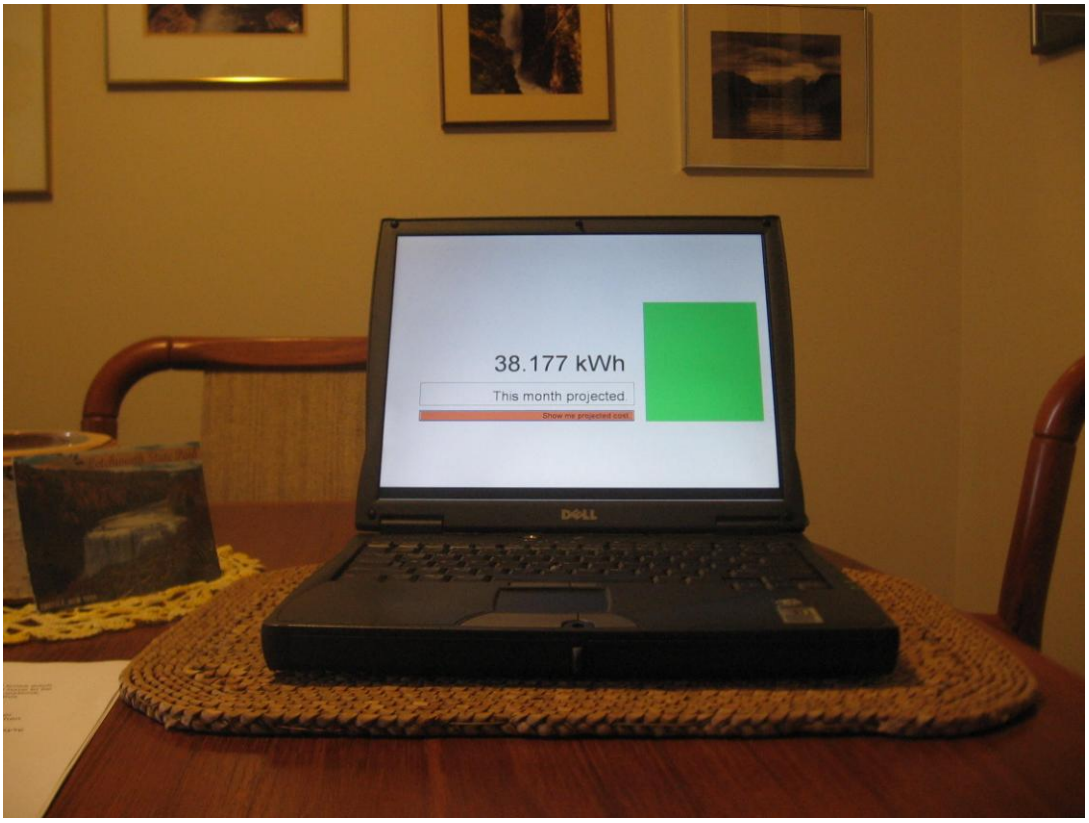


Typical Module



LED Module (above)

Display with Projected Cost

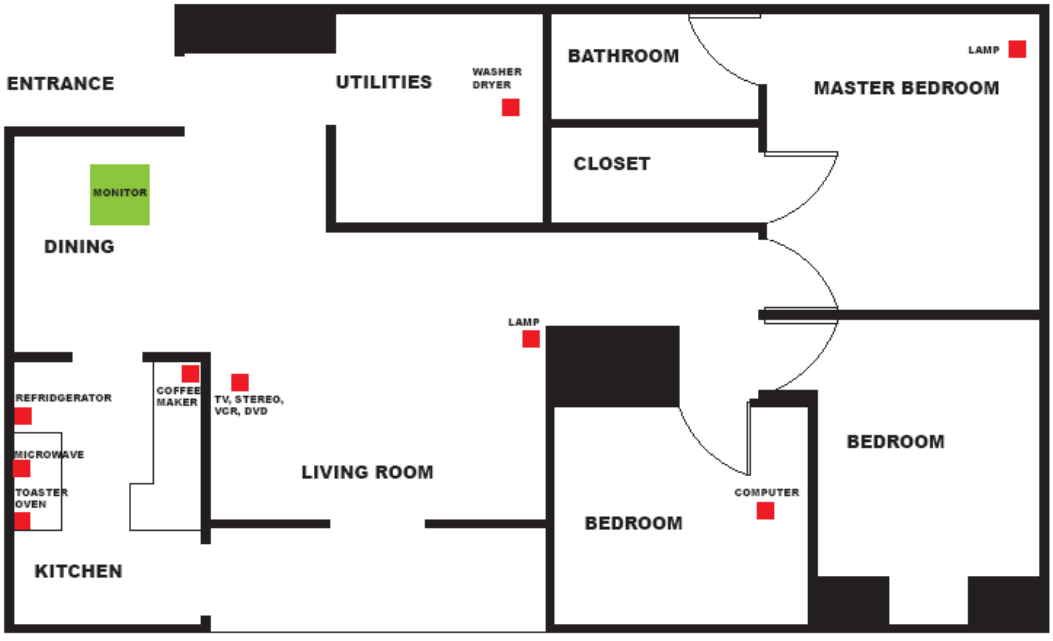


Display with Kilowatt-hours

Installation of a Module (microwave)

GARAGE DOOR

NANCY COWGER APARTMENT - INSTALLATION #2
(3/11/07 - 3/14/07)



3.0 Revised Task/Event Schedule

Although the general layout and ideas of our project have stayed in place, there have been a couple of changes in the timeline and phasing. The biggest change was the decision to do multiple test phases with different iterations of our prototype in order to attain user feedback, create modifications, and test the new prototype again. We feel this is key to discovering what type of feedback creates awareness of resource consumption for the user.

The team has had success in this project. The Market Research team, after preliminary research and scenario plan investigation, is working on potential methods of installation for the product and will be able to present this at the end of the semester. The Survey team has created an online survey that targets the designated user group and has worked to find individuals to test the prototype. Within the prototype and testing realm, orientation materials have been created for the prototype, user interface designs have been completed, and two tests have been run using two versions of the prototype. Plans for one more test are underway and it is desired that a fourth test will be completed before the end of the semester. Although there have been difficulties, the project has seen significant progress over the first half of the semester.

The teams have been divided for the project tasks based upon the skill sets of team members that are shown in the skill chart in section 4.0. See attached Gantt schedule for detailed task information as well as which team is assigned to each task.

4.0 Updated Task Assignments and Designation of Roles

While the teams we created in the Project Plan are still valid, we have added other sub-teams to address specific problems that have arisen with the design of the prototype and testing phases.

Team Descriptions

Planning/Deliverables: Team leader – Jessica Henson

The Planning/Deliverable team will put together a draft of the project plan for the team to review, and as the project continues, oversee the completion of the IPRO deliverables including the midterm report and final report.

Business Plan: Team leader – John Kestner

The Business Plan Team will research marketing techniques and strategies and determine the best way to market the product to the intended user.

User Research: Team leader – Jordan Fischer

The User Research Team will create and distribute questionnaires and interviews for the target users, collect the data, and summarize the data.

Synthesis: Team leader – Nick Perry

The Synthesis Team will analyze the data collected to form design criteria, as well as collecting data from prototype testing and analyzing results.

Design: Team leader – James Pierce

The Design Team will develop a design and create a prototype that accomplishes the appropriate feedback for the determined user and addresses all the specific design criteria and parameters. They will also test the prototype on a variety of people in diverse home settings.

Production: Team leader – Sarah Jones

The Production Team will compile all data and design the final material used for presentations on IPRO day.

Sub-Team Descriptions

Orientation/Introduction: No assigned leader.

The purpose of the Orientation/Introduction Team is to come up with a simple way to explain the project and how the device works to the user that will be testing the system. When the product is installed in the test users' home, a team member will be there to introduce them to the devices, explain the process and answer any questions they might have.

Feedback: No assigned leader.

The Feedback Team is brainstorming ideas to figure out how best to give feedback to the test user and how to change the feedback in between test to make it more affective/useful for the next test.

Scenario Plan: No assigned leader.

The Scenario Plan team is looking at what exactly are product will do, who the users will be, what price it should be sold at and how to market our finished product.

Installation/Uninstall Crew: No assigned leader.

The Installation Crew consists of various members depending on availability and confidentiality of test site, who go into the test users' home and install the devices on electronic equipment and set up the feedback devices. After the testing period has commenced, they will go to the users' home and uninstall all equipment and feedback devices.

Prototype: No assigned leader.

The members of the Prototype team actively participated in buying supplies/materials, designing and building various feedback prototypes to be used during testing.

Data Analysis: No assigned leader.

The members of the Data Analysis Team will decipher data collected by the computer during testing and figure out how it relates, how useful and how it can help us further the design of the device.

Last Name	First Name	Major	Year	Skills	Attributes	Team/Tasks
Cawvey	Jessica	Architecture	4	Autocad Microsoft Office Suite Adobe Illustrator Adobe Photoshop	Organized Creative Hard-working	Planning/ Deliverables, Feedback, Prototype, Collection of Materials and Supplies, Presentation
Christensen	Carissa	Architecture	3	Autocad 3D Studio Max Microsoft Office Suite Adobe Photoshop	Organized Happy Creative Visual	Planning/ Deliverables, Orientation/ Introduction,

				Rhino Dreamweaver	Hard-working	Install/Uninstall Crew
Dannhausen	Anna	Architecture	4	AutoCAD Accurender (AutoCAD 3D rendering program) Microsoft Office Suite Adobe Illustrator Adobe Photoshop Dreamweaver	Organized Personable (good with phone calls and dealing with people)	Business Plan, Scenario Plan, Prototype
Fischer	Jordan	Design	Grad	Adobe Photoshop Adobe Illustrator Adobe InDesign Macromedia Flash Macromedia Dreamweaver Rhino (surface modeling) Maxwell (rendering software) Photography Videography Rough Prototyping Interviewing	Extracting Meaning from complex data Motivation Consensus Building Creative Direction Improvisation Framing problems to provide a new perspective Leading during the generation of ideas, and following during the implementation of ideas.	User Research (Leader), Orientation/ Introduction, Install/Uninstall Crew
Henson	Jessica	Architecture	4	Autocad 3D Studio Max Microsoft Office Suite Adobe Illustrator Adobe Photoshop Mathcad SAP2000 Dreamweaver	Organized Leadership Outgoing Hard-working	Planning/ Deliverables (Leader), Feedback, Install/Uninstall Crew, Prototype, Collection of Materials and Supplies
Herrera	Stephanie	Architecture	4	Autocad 3D Modeling Animation Adobe Suite Microsoft Office Suite	Organized Enjoys working with hands Research	User Research, Orientation/ Introduction, Install/Uninstall Crew, Prototype

Jones	Sarah	Design	Grad	Adobe Photoshop Adobe Illustrator Adobe InDesign Macromedia Flash Macromedia Dreamweaver Rhino Solid Edge AutoCad Matlab Pbasic Page Layouts	Rendering Implementation Delegating	Planning/ Deliverables, Feedback, Install/Uninstall Crew Production Leader
Kestner	John	Design	Grad	Program in Java, Basic Stamp, etc Write HTML	Communicate effectively with words, illustrations, photos and models Design user-centered products and interfaces that look good and communicate what they're about	Business Plan (Leader), Feedback, Install/Uninstall Crew
McLeish	TJ	Professor	Prof	n/a	n/a	Professor
Perry	Nicolas	Architecture	4	General Computer Skills (above average) Adobe Suite CS2 AutoCad Microsoft Office Suite Laser Cutter 3D Studio Max Sketchup Wood Shop Soldering electrical Circuits Knowledge of electronics concepts and components (beginner) Project scheduling and cost estimation	Organized Fast learner	Planning/ Deliverables, Orientation/ Introduction, Install/Uninstall Crew, Prototype, Synthesis (Leader)
Pierce	James	Mathematics	4	Adobe Photoshop Adobe Illustrator Macromedia Dreamweaver Java Eclipse Machining Welding Fabrication	Learning new skills (e.g. electrical/hardware)	User Research, Feedback, Install/Uninstall Crew, Prototype, Design Leader

				Research, exploration, and analysis		
Popov	Nikolay	Mechanical Engineering	3	AutoCAD Microsoft Office Suite Basic C++ and Matlab Basic Electronics	Honest Caring	Business Plan, Feedback, Data Analysis, Install/Uninstall Crew, Prototype
Puschkar	Jackie	Business	2	Microsoft Office Marketing Business strategies	Personable Organized	Business Plan, Scenario Plan
Wong	Jacintha	Business	4	Adobe Photoshop AutoCad 3D Studio Max Microsoft Office Suite	Artistic	Business Plan, Scenario Plan

Designation of Roles

Role	Description	Assigned to
Master Schedule Maker	Responsibilities include planning a master schedule and keeping it current	Jessica Henson
Meeting Minutes Taker/ Organizer	Responsibilities include taking minutes of each meeting, recording the information on a standard form, and uploading minutes on to igroup site. (see grading criteria for specific details)	Jessica Cawvey
Meeting Agenda Maker/Timekeeper	Responsibilities include meeting with Master Schedule Maker and putting together a Meeting Agenda for each class. (see grading criteria for specific details)	Nicolas Perry
Weekly Status Reporter	Responsibilities include developing an individual Weekly Progress Report form, compiling a weekly status report that includes Meeting Minutes, Meeting Agendas, and Weekly Progress reports from each team member. (see grading criteria for specific details)	Jacintha Wong
Igroup Coordinator/ Communication Facilitator	Responsibilities include collecting all contact information and posting on igroups as well as keeping the igroups site and folders organized	Jacintha Wong
Webmaster	Responsibilities include setting up and design, and maintaining website for class	John Kestner
Treasurer	Responsibilities include maintaining the budget, collecting receipts and turning them into the Ipro office for	Jessica Henson

	reimbursement.	
Head Researcher/ Historian	Responsibilities include applying to the internal review board for project testing and delegating necessary research as well as photographically documenting the progress of our project	Jordan Fischer
Presentation Coordinator	Responsibilities include delegating and managing all assignments that need to be done for final presentation on IPRO day and assuring all material is received on time.	Sarah Jones

5.0 Barriers and Obstacles

Market Research:

The main obstacle to overcome in the market research is obtaining the type of data needed rather than the data readily available. Most of the research that has been found is in the way of statistics and number comparisons. While this information is not altogether invalid, a more useful data type is needed for our project in the way of marketing strategies for energy reducing products and how to best create and market an energy awareness product so that it will be successful on the marketplace despite the largely apathetic population. The team is working on finding marketing data for similar energy saving products.

Feedback/Testing:

Surveys were written and placed on an internet survey site and then filled out by volunteers. However, because the surveys stood alone without any context of a prototype to provide additional energy feedback to the volunteer, the feedback from the surveys we received back had little to no value for informing prototype design. The obstacle that this created is that the feedback is reliant on in-house testing, which takes much more time than just handing out surveys. It is also much more intrusive and intensive of a process for both the team and the volunteers. It is harder to find people who are willing to have the prototypes in their houses for an extended amount of time and who care enough to interact with the prototypes. The majority of the team's contacts range in age groups that do not own houses nor pay for their

own energy bills. However, the team has found a few volunteers that are interested in opening up their houses to the prototype testing and from there we hope to gain even more contacts in order to perform even more tests. Though time is not something we have in abundance, the team is working hard to get as many tests completed within homes as possible in order to best inform the final design solution.

A large obstacle that the team is addressing currently is that one of our RF1 receivers has been ceasing to collect data after about twelve hours of testing for an unknown reason. When trying to collect data on a three day in-home test, it is inconvenient to end up with only twelve hours of usable data. We are in contact with the manufacturer and are in the process of a debugging experiment to uncover the problem and get it fixed so as to continue with the prototype testing.

An obstacle to overcome within the group is the lack of technical background. Much of our project's process involves creating and recreating software interfacing and prototype circuitry. The majority of our group members have no background in these fields. We are working closely with the few team members who do possess such knowledge to accomplish the changes in prototypes needed.